# Enhancing Icing Training for Pilots Through Web-Based Multimedia

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## Abstract

The Aircraft Icing Project of the NASA Aviation Safety Program has developed a number of in-flight icing education and training aids designed to increase pilot awareness about the hazards associated with various icing conditions. The challenges and advantages of transitioning these icing training materials to a Web-based delivery are discussed. Innovative Web-based delivery devices increased course availability to pilots and dispatchers while increasing course flexibility and utility. These courses are customizable for both self-directed and instructor-led learning. Part of our goal was to create training materials with enough flexibility to enable Web-based delivery and downloadable portability while maintaining a rich visual multimedia-based learning experience. Studies suggest that using visually based multimedia techniques increases the effectiveness of icing training materials. This paper describes these concepts, gives examples, and discusses the transitional challenges.

## I.    Background

The Icing Research Branch of the NASA Glenn Research Center recognizes the value of pilot education and training as key components in reducing icing-related aircraft accidents and incidents (ref. 1). They engaged Glenn's Imaging Technology Center to bring visual story-telling and filmic techniques to this training initiative. Over the past several years, the adoption of various media technologies in the delivery of these educational materials and training aids has been promising both in the effectiveness and retention of these materials within the target audience of pilots and dispatchers (ref. 2).

Our first stand-alone training aids were videotaped presentations. This robust visual medium offered highly detailed photographs, video, graphics, and animations. However, this approach could be time consuming for students and did not lend itself to a classroom environment.

As delivery mediums matured, we adopted a user-interactive computer-based training approach using both CD–ROM and DVD formats; examples are shown in figure 1. We primarily used the same content structure and distribution that had been established for our video training. One or more disks were mailed to a requester at a time. Although very well received by the world piloting community, these methods had very high distribution costs. For this training material to make a real impact in the user community, a wider distribution mechanism was sought.

Over the last 10 years, the Internet has grown to play a much greater role in the successful delivery of education (ref. 3). Internet-based training products offer increased flexibility, centralized updating, better version control, wider distribution, reduced distribution costs, and unlimited user access. Using the current NASA distribution model, which involves no cost to end users, makes the Web an ideal method of delivery. The no-cost status eliminates the need for login screens and financial verification, and it avoids most pirating problems. NASA actually encourages the copying of its training materials in their totality.

Figure 1.—Pilot training line, including video,
computer-based training, and DVD products.

This increases awareness and expands pilot education at no additional cost. The Aircraft Safety Office and Glenn's Icing Branch have embraced Web delivery for pilot training and have created two online courses for pilots: *A Pilot's Guide to In-Flight Icing* and *A Pilot's Guide to Ground Icing* (ref. 4).

## II.     Goals of the Transition

We hoped to meet several goals by transitioning delivery of the training to the Web: (1) to reach a greater audience, (2) to increase the flexibility and utility of the training, (3) to increase on-demand training capabilities, and (4) to reduce distribution costs.

## III.     Challenges of the Transition

Web delivery, being relatively inexpensive as it relates to distribution, presented a few technical tradeoffs that we had to negotiate. In keeping with successful training efforts that relied on linear delivery technologies, we wanted to maintain the rich visual nature of a video-based presentation. This is required by the visual nature of icing accretion data and demanded by the sophisticated nature of today's users.

These requirements had to be balanced with the need to use lower bandwidths to download graphic pages from the Web. In addition, because Web connectivity can be difficult or nonexistent in remote areas like far northern Canada and Alaska, we wanted to be able to disseminate the courses on disks as well as on the Web.

Several things were considered:
- Programming to a basic hardware requirement
- Software inclusion and/or availability to clients
- Bandwidth usage, motion pictures, and download time
- Single or multiple disk portability

### A. Understanding the User Audience

Although the target audience is technically savvy, to successfully provide a Web-based, multimedia product, we still needed to determine the technical capabilities and connection speeds available to end users. On the basis of general industry surveys (ref. 5), we estimated that approximately 50 to 60 percent of Internet users in the United States have "high" bandwidth connectivity (DSL, cable, LAN, etc.).

Therefore, we assumed that about half of the course users would be viewing the content via a dial-up connection, which creates challenges for any multimedia program. Furthermore, in our discussions with various trainers and pilot associations, it became clear that a majority of users do not have the most current computer hardware or higher connection speeds to the Internet.

Consequently, hardware and software requirements for the courses were kept as simple as possible. The courses were designed using Macromedia Flash (Adobe Systems Inc., San Jose, CA), not only because it is a highly developed multimedia production tool for the Web, but because the Flash Player software is installed by default on the vast majority of computers accessing the Internet. In addition, the Flash Player software is available for Microsoft Windows (Microsoft Corporation, Redmond, WA), Mac OS (Apple Computer, Inc., Cupertino, CA), and many Unix and Linux variants. It is free and installs easily if needed. In addition, player software can display or play most media types (images, video, etc.), negating the need for other platform-dependent playback software such as Windows Media (Microsoft Corporation) or QuickTime (Apple Computer, Inc.).

## B. Bandwidth Conservation and Optional Media Selections

Rich visual media resources, such as video, that require higher bandwidth connections have been made optional in the course. Users are presented with a representative still image along with an identifying label and an approximate file size of any optional video selection. In this way, users can determine if the subject is of interest and if the file size is suitable for their given connection speed. As a user views the main course content onscreen, the video is loading in the background, so if a user chooses to view the video, some or all of the video content will be available immediately (fig. 2).

The idea of "related information" is used liberally throughout the courses. These optional selections consist of peripheral information and are not critical to an understanding of the core lesson. These selections add to the depth and variety of the educational experience. Icons representing various types of related information appear in a consistent location on screen, and mouse rollovers provide the user with a description of the available information. Selecting an icon presents the related material to the user in a separate browser window that functions independently from the main course section. Users can proceed with a main course section while related content loads in a separate window. This conserves bandwidth and reduces wait time (fig. 3).
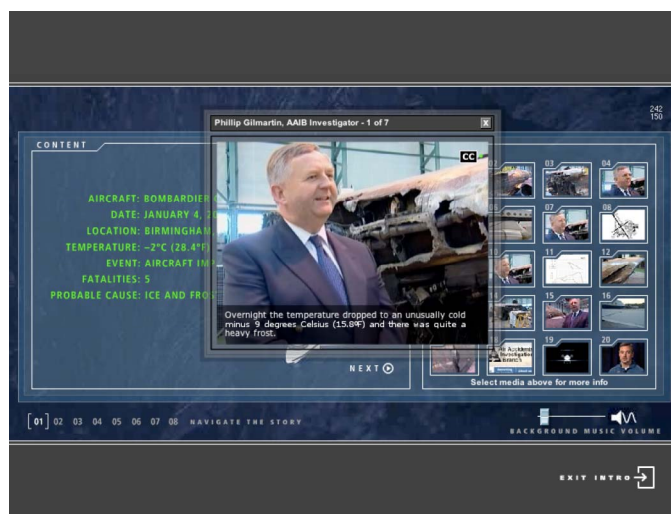


Figure 2.—Movie popup of Captain Philip Gilmartin
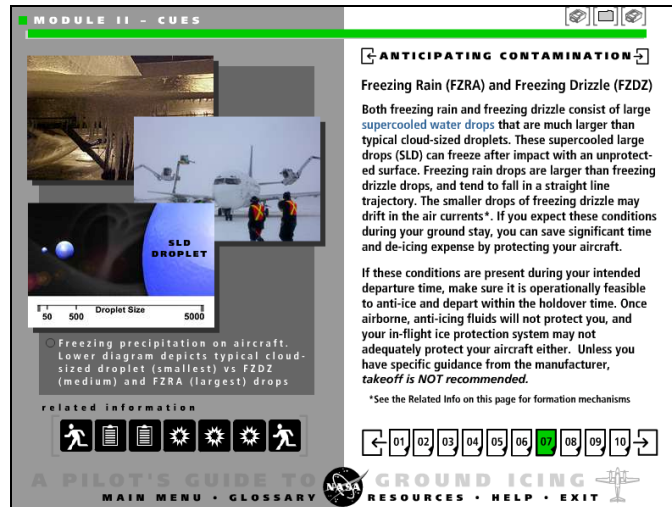displayed on top of the introduction
of a Web-based course.

Figure 3.—Typical Web-based course page with related information choices in the lower left.

## C. Visual Asset Management

Bandwidth-intensive resources and related information elements (e.g., aircraft accident and incident reports, animations, and on-camera interviews) are stored as discrete linked files. These files are loaded either in the background, which does not affect user performance, or on user demand. All the courses are based on the concept of small, modular linked files that contain the minimum amount of content needed at any given moment. The course uses "preloaders" to load upcoming information as a user views other content.

## D. Version Control

Maintaining a single, consistent course version for all users is simplified by offering the course from a single Web server. Changes, updates, and modifications can be made to a single set of source files, which then become available immediately to all course users. If the course changes significantly, developers can change the version number. This purges the locally stored tracking data and alerts the users that the course content has changed.

Since the courses were designed using "relative" paths to linked course sections, resources, and media, we were able to bundle the course into an archive (ZIP) package for download. The stand-alone version of the course functions exactly the same way it does on the Internet, with the exception of a few external site links that will fail if an Internet connection is unavailable.

Obviously, allowing users to download the courses creates a problem in terms of version control. Users might continue to use a downloaded course unaware that the online version has changed. To alert users, we clearly noted this problem on the first hypertext markup language (HTML) page that a user views when starting the stand-alone version of a course. We also request an email address from those who download a course package so that we can notify users if an online course has been updated (see fig. 4).

Allowing course downloads also affects usage statistics. Stand-alone use of a downloaded course, such as in a training facility, cannot be incorporated into usage statistics linked to a Web server. This reduces the overall course usage numbers and makes the true effectiveness of a course ambiguous.
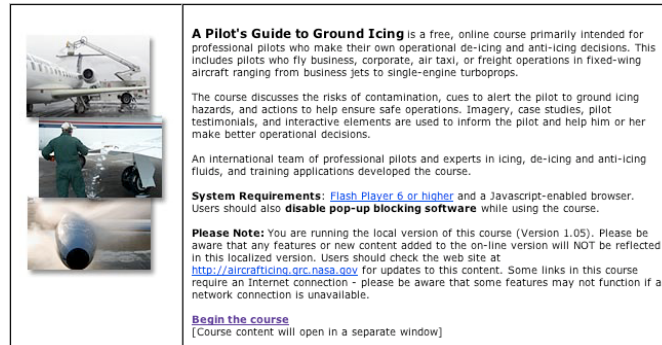
Figure 4.—HTML screen capture of a stand-alone course.

### E. Privacy

Since a course uses only local storage of persistent data, users can be assured that data are not being tracked or stored online. It is made clear within the courses how data are managed, reassuring users that no performance data are transmitted or stored.

### F. Accessibility

Every effort has been made to create courses compliant with relevant portions of Section 508 of the Rehabilitation Act. Features such as embedded descriptive text and keyboard control have been included to aid users with various disabilities in navigating and using the course. Improvements in the ground icing course include rollover image labels and closed captioning of all videos.

## IV.    Benefits of the Transition

### A. Interactive Learning

One key benefit of transitioning to a computer- and Web-based product is a greater opportunity for user-driven interactive learning. As educators, we hoped to include in the icing courses interesting and effective interactive elements that were designed from the pilot's point of view. These interactions were impossible to do within passive presentation methods.

We attempted to reinforce important aspects of aerodynamic balance, icing-induced lift and drag penalties, weather phenomena, and deicing fluid type and application in an interactive manner using a familiar preflight methodology. Interactive discovery is utilized throughout the presentation.

### B. Interactive Discovery

Interactive discovery is exemplified by the methods used to access related information, and it complies creatively with bandwidth conservation. As an example, rather than waiting for a lengthy video to download to introduce the course, a user can choose from many attractive but optional choices in the opening sequence. This allows a user to decide what is important given the time availability, connectivity, and previous instruction (fig. 5).

Figure 5.—Interactive screen showing aircraft
deicing spray zone.

# V.    Course Features

A number of features have been incorporated into the courses to provide flexibility and usefulness. These features have been included as a result of experience in developing disk-based courses, feedback from instructors, and suggestions from previous users.

## A. Persistent Data Storage

For the courses to be more functional and easy to use on subsequent visits, some persistent data storage mechanism is required to save user information, such as progress, bookmarks, and syllabus customization, between sessions. Since the hypertext transmission protocol (HTTP) is essentially a "stateless" network communication, some other form of session or data storage is required. There are numerous methods available to save this form of data, but most require a database on the server side.

Because of privacy concerns and cost, a decision was made to use the local storage mechanism provided by Flash Player software. This storage area exists only on the local or client system. By default, the Flash Player software provides 100 kB of storage per domain. Users can change the amount of storage or even disable it if desired, and developers can prompt users to increase the allowed storage. In the case of our courses, relevant data are stored and retrieved each time a course is used on a particular client system. The advantages of the client-side storage model are assurances of privacy to the end user and elimination of the need for a more costly server-based user database. The disadvantages are a lack of ready statistical data on course usage habits, since none of these data are transferred to the server. Also, since client data are stored on the end-user system, they are tied to a specific computer and not the user. This identity does not "roam" with users to any other system or network where the courses might be accessed.

## B. Layered Architecture

Macromedia Flash uses the concept of "levels" for loading and stacking movies in z-order as seen by the viewer. This allows developers to load often used movies at the lowest levels of view and less needed movies on top of them. In the case of our learning courses, the main menu is loaded at the lowest level, course sections in the level above, and resources at the highest level. This scheme allows the user to load the main menu graphic page only once, keeping it in memory and onscreen at all times. When a course section or resource loads on top of it, it merely hides the main menu, which is instantaneously revealed

when the course section unloads. The same holds true when a resource section loads on top of a course section. The benefits to users are bandwidth conservation and immediate visual response.

## C. Course Syllabus

Users are presented with a list of course sections available on the main menu screen. Although course sections are listed in a progressive order, users can start a course from the beginning, move directly to a section of interest, or continue with the section last viewed (see fig. 6). When a user returns to the main menu screen, progress through the course sections is noted along with the section name. An indication of whether the section has been started or completed also appears. Users can edit or customize the course syllabus if desired and remove sections so that they do not appear on the main menu screen. Currently, course sections cannot be reordered.

## D. Bookmarks

Users can bookmark any page within a course and then view the saved bookmarks by selecting a button on the main menu screen. Each bookmark allows a user to immediately navigate back to that page within the course. In addition, short notes can be attached to each bookmark. Bookmarks, along with user notes, can be printed.

## E. Printing

Buttons for printing appear in a consistent location on all course pages, allowing users to print single course pages or entire course sections. This feature is useful for those wishing to review or share course material. In addition, some checklists and tables can be printed from within the course.

## F. Keyboard Control

Some often-repeated actions, such as navigating to the next or previous course page, have been assigned keystrokes for simpler usage. Keyboard modifiers, such as the "Control" key, also have been added to allow users to move between course sections.
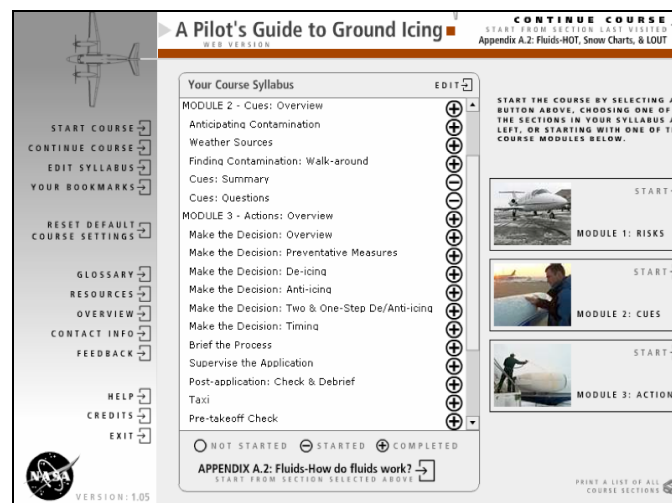


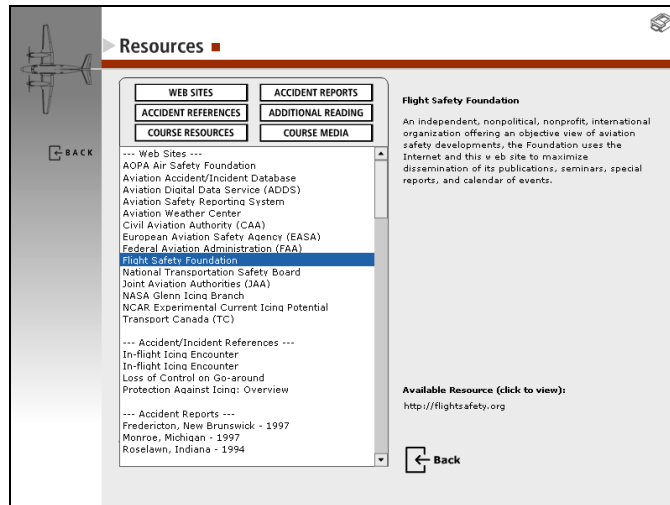Figure 6.—User-selectable course syllabus screen.

Figure 7.—User-interactive resource-selection screen.



Figure 8.—English and French marketing posters.

## G. Resources

All related information presented in the course, along with related Web links and papers are available in one location in the courses. Any item can be viewed from this list of resources. Other features of note include a glossary of terms, enlarged preview images, rollover image descriptions, high-resolution image downloads, and closed-captioned video (fig. 7).

## H. Course Download Capability

Currently, the aviation courses can be downloaded for use on a local computer (ref. 4). This option arose through multiple requests from trainers desiring to use the course during classroom presentations without being dependent on an Internet connection or available network bandwidth.

## I. Marketing Information

Although the Web offers the courses to a far greater audience at a reduced dissemination cost, a greater effort had to be put into marketing the Web sites to make the material effective. Both traditional and electronic advertising techniques were used. Traditional hard-copy posters (fig. 8) and press releases

were created as well as electronic versions of this material. NASA and its partners used this material to advertise not only the release of the ground deicing course but to highlight the international partnership to a multinational user base. The posters use catch phrases and slogans to direct pilots under three different worldwide regulatory areas of authority to the Web site.

# VI.    Future Directions

User feedback is a critical part of any ongoing training development program. We continue to gather and incorporate unsolicited user feedback and evaluation. This information accurately targets, improves, and enhances the learning material and delivery methods. We hope to generate more feedback from users by incorporating an online survey and a suggestion section as part of the course.

Glenn's Icing Branch is considering several future enhancements to the current Web-based training in the areas of general aviation and rotorcraft. We are looking at developing a companion module for ground icing training aimed at the needs of general aviation pilots—specifically pilots who fly smaller personal and business piston-driven aircraft. Rotorcraft icing training also is being developed. Release dates for these products have not yet been determined.

# VII.    Conclusion

Significant benefits resulted in transitioning icing training to a Web-based delivery system. Distribution costs were reduced while audience penetration was increased significantly. With some creative innovations, the high-bandwidth, rich video- and motion-picture-based content could be managed. We have maintained the visual story-telling techniques that made the video-based courses successful and incorporated these elements onto a viable Web design with increased availability, flexibility, and utility.

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